DISTRIBUTION OF FOLLICULINA IN 1914.

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The finding of vast hordes of the *Stentor*-like infusorian *Folliculina* both in 1912 and 1913 throughout the whole extent of the Severn River which is a brackish side branch of the Chesapeake Bay, led to further examination in 1914 to see if this were a phenomenon to be repeated annually or only a rare inroad of an outside fauna into new territory.

In 1913[1] *Folliculina* was found in inconceivable numbers living upon the leaves of the fresh water plants *Elodea* and *Potamogeton*, which have taken possession of definite zones of shallow brackish water along some fifty and more miles of extent of the river and its side creeks. It was also found on *Elodea* in Whitehall River, just to the north of the Severn.

In 1914 it was taken on *Elodea* from the head of the Magothy River, August 13, and on floating *Elodea* in the mouth of the Magothy, August 23, when it was also found living upon stunted *Elodea* growing in the narrow inlet canal to the nearly shut off side branch known as the Little Magothy. It was taken also at Deep Creek, a side branch of the Magothy.

As the Magothy opens into the Chesapeake some seven miles from the Severn, the distribution of Folliculina is quite extensive. Moreover, in 1880 Ryder[2] found *Folliculina* in great numbers upon oyster shells in shallow water on the west coast of the Chesapeake, and as he seems to have then been at St. Jerome, St. Mary's County, which is sixty miles down the Bay from the Severn, the distribution of *Folliculina* is known for side branches of the Bay opening into it seventy miles apart, approximately.

It is to be expected then that exceedingly large areas of the side waters of the Chesapeake may be inhabited by this little-known protozoan, which in the mid-summer season adds greatly

[1] See Biol. Bull., XXVI., No. 4, April, 1914.

[2] *Am. Nat.*, 14, 1880.

to the plankton, or swimming fauna, as well as to the microscopic life attached to the summer vegetation of these waters.

Its advent and departure in Chase's Creek, a branch of the Severn, showed in 1914 even more suddenness than in 1913, while its time of abundance was noticeably less though actual numbers present were even more vast.

Though searched for from the middle of June, every few days, *Folliculina* was found first on July 19, 1914. It then appeared only here and there, not on every plant of *Elodea* and on very few plants of *Potamogeton*. On the sprays of *Elodea* the *Folliculina* showed on comparatively few leaves, like black soot stuck on the leaves; both isolated individuals and aggregates occurred

FIG. 1. Leaf of *Potamogeton* showing scattered colonies of *Folliculina*. ×3 diam. Photograph of preserved specimen.

but there were very few large aggregates covering half the surface of a single leaf. Most leaves had none, some leaves had many scattered individuals. On the stems there were noticeable numbers of the small form of sac. The occurrence on leaves seemed entirely arbitrary as if from settlements of swimmers: the *Folliculina* was not now crowded toward the tips of the sprays but scattered along many inches of the spray.

At the date of this first appearance, jellyfish had been common for two weeks but the other conspicuous summer visitor to these waters, the young menhaden now for the first time came along the shores over the *Elodea*, which may be correlated with the

feeding of the menhaden upon plankton in which the free swimming *Folliculina* may be included as possible food for the menhaden.

At this date the *Elodea* had grown up to a height of twenty inches and formed some flower stalks and buds at the surface, so that there had been a long period in which suitable attachment base for *Folliculina* was present but the *Folliculina* had been absent.

July 21 the water after long drought was turbid from the presence of plankton and the *Folliculina* had increased but little, appearing as black spots on one out of several hundred sprays of *Elodea* and one out of many thousands of *Potamogeton* sprays. Only a few of the leaves on each inhabited spray had dense aggregates, so that the question arises: why do the *Folliculina*

FIG. 2. Tip of leaf of *Elodea* covered with a colony of *Folliculina*. × 15 diam. Photograph of preserved specimen.

crowd together in these rare, isolated aggregates? When sprays of these dates were put into aquaria they gave rise to free swimming forms, thus showing that these early settlers need not remain fixed but might contribute to additional distributions.

On July 27 *Folliculina* had become much more abundant upon sprays of *Elodea* and *Potamogeton;* some of the free-floating fragments on the surface appeared black with the accumulated

Folliculina. In the water also some free-swimming *Folliculina* could be seen near the surface swimming all through the water as well as close to floating plants.

Out in the Severn River a two-quart jar of water taken up at random at the surface showed several free-swimming *Folliculina;*

FIG. 3. Photograph of a preserved colony that had been formed on surface of the water in aquarium; showing form of case and tube spirals as well as animal rectracted within case. Enlarged 30 diameters.

three days later these had settled down on the side of the jar and were in two groups, two individuals in one and five in the other, so that at least seven were in the two quarts of surface water, which would make an immense number for the entire river.

By August 1 much of the *Elodea* growing in the *Elodea* zone along shore was black with aggregates of *Folliculina*. Free swimmers were in the water of the creek in vast numbers: a quart dipped from the surface at random showed in a white bowl from fourteen to one hundred, by actual count, for each quart of water from the surface. By drawing the bowl along the surface, the *Folliculina* swimming free were concentrated till thousands in a quart made it dark as if sprinkled with black pepper. Though these free-swimming Folliculinas easily escape notice in the greenish water turbid with plankton and sediment, they are readily observed in calm water by an eye near the surface; and standing in water five feet deep one may see them swimming

FIG. 4. Photograph of two young colonies of free swimmers that have just settled on surface of water in aquarium and formed sacs but no tubes: one individual on extreme left is still in motile form. Preserved specimen, × 20 diam.

rapidly in all directions, individually in straight and in curved paths. Many deep down in the water were seen best by holding a white object below them, but most of them were near the surface where they congregated especially about any floating object as fallen leaf or floating chip, seemingly influenced by its presence so that they swam toward it.

While at this time the *Folliculina* continued to colonize the new growths at tip of the *Elodea* as fast as it grew so that the

black aggregates crowded on the young leaves nearly to the tip where only the newest leaves were as yet unoccupied; by August 18 the extension of the *Folliculina* hosts had ceased. The tips of the growing *Elodea* were now bare or free from *Folliculina* back some twenty leaves from the tip and many of the old dwellings on the lower leaves were deserted. These dense black colonies on old leaves contained in fact but few living Folliculinas.

FIG. 5. Photograph of natural size sprays of *Elodea* preserved to show successive phases of colonization in 1914. Spray on left has grown enough to form flower but as yet but a very few isolated individual *Folliculina* have settled upon it. The next spray shows scattered tubes all along its length. The third spray shows dense aggregations of colonies even up to the tips of the rapidly unfolding new leaves. The fourth spray illustrates the subsidence in colonization: the new colonies no longer cover the leaves at the tip of the spray but these grow more rapidly than the new colonists occupy them and are left more nearly free from any Folliculinas.

By August 26 this falling off in the colonization and rapid disappearance of *Folliculina* was most pronounced: the *Elodea* sprays showed an abrupt transition from the lower leaves black from dense population of tubes, for the most part empty, to the upper leaves only sparsely inhabited with scattered individuals. Evidently some sudden change had operated not only to check the previously rapid spread of the Folliculinas onto new leaves but to

almost exterminate them. Yet many remained alive here and there so that when large quantities of the *Elodea* were put into aquaria many free swimmers escaped. Yet these after forming new tubes on the surface of the water did not remain alive but had all vanished September 5, though in such apparently normal environment others had been kept two weeks in captivity earlier in the season.

Thus while appearing after the middle of July and being extraordinarily abundant in August, the *Folliculina* were all gone about the end of August and no way was found of keeping them longer. Their period of existence in accessible regions of the river was scarcely six weeks.

In 1913 they appeared before the end of June and a few lingered on to the first of September in nature and were kept in aquaria in a warm room till the 27th and a few till November 11.

In 1912 no live ones were found after September 8. This enormous crowding of the waters with free-swimming *Folliculina* and dense settlements of the case-making Folliculinas during about a month, the last weeks of July and the first of August, coincides with very high temperatures and abundance of microscopic plankton in these waters but it is not at all evident either why the Folliculinas should not come earlier, as they did in 1913, or remain later as they did in 1913 and 1912.

The great rapidity of their colonization of large areas suggests either very great immigration or else very rapid multiplication, or combination of both. As all material searched in the daytime in 1913 failed to show more than a few cases of multiplication, most all the free-swimming forms being merely the case-making forms again freed, material was collected at all times of the night in 1914, but here again but few cases of division were observed.

Hence it seems unlikely that fission of a few immigrants actually produced the vast numbers found on the leaves of plants, and it is probable that very large numbers came into the river suddenly from some outside source and these settling down, migrating out again, and in some cases increasing by fission, gave rise to the succession of dwellings covering the leaves for some two months.

The causes leading to the immigration as well as the causes of rather sudden diminution of numbers and utter disappearance remain entirely unknown.

The food of the case-inhabiting *Folliculina* being bacteria and some larger forms of plankton, the disappearance of *Folliculina* may well be associated with changes in food supply, in turn brought about in connection with such changes as those of temperature and salinity.

The motile forms take no food and may be enabled to settle and to continue migration and multiplication only when feeding conditions allow the sessile form to accumulate enough energy.

Summary.

1. The vast swarms of swimming protozoans of the genus *Folliculina* that were found to settle down over the aquatic plants along the shores of side branches of the Chesapeake Bay in 1912 and 1913, came in even greater numbers in 1914, and it is therefore probable that this immigration and colonization is a regular annual phenomenon.

2. The incursions of swimming *Folliculina* do not take place as soon as the plants have grown enough to supply places for attachment, and the departure or disappearance of the living Folliculinas antedates the cessation of growth and final dying down of the plants upon which they settle.

3. As far as evidence is available the numbers that crowd the leaves arise more from immigration from without the area than from division of animals that have already settled in the area.

4. The times of appearance and disappearance differ in successive years.

5. It is suggested that conditions of food possibilities are determining factors in these inroads into the brackish fauna.

6. The great number of free swimming forms makes them, for the time being, an important factor in the plankton.

7. The crowding of the dwellings or cases on the leaves all along the shores is a considerable element in the transformation of matter which, arising from decay of organic materials, is transformed into bacteria and other plankton organisms, which in turn are eaten by *Folliculina* and enable them to secrete resisting tubes and sacs which finally settle to the bottom of the river.